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The Process Of Functioning of the "Excavator - Cars" Systems From The Perspective of The Theory of Operations Research

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Annotation: The article discusses the process of functioning of the "excavator - cars" systems from the perspective of the theory of operations research.

Keywords: excavator, machine, operation system, vehicle, car.

Introduction

Considering the process of operation of an excavator, described by expressions, from the standpoint of general systems theory [1], we can conclude that in this case the system consists of three elements: "the object being developed - the excavator - the dump." Examples of such systems are: digging pits, trenches, etc. In such cases, the work (functioning of the system) is not influenced by any technical participants in the process, and the excavator simply sends the excavated soil to the dump.

According to the formulas listed above, the excavation process seems to be continuous throughout every hour (Fig. 1).

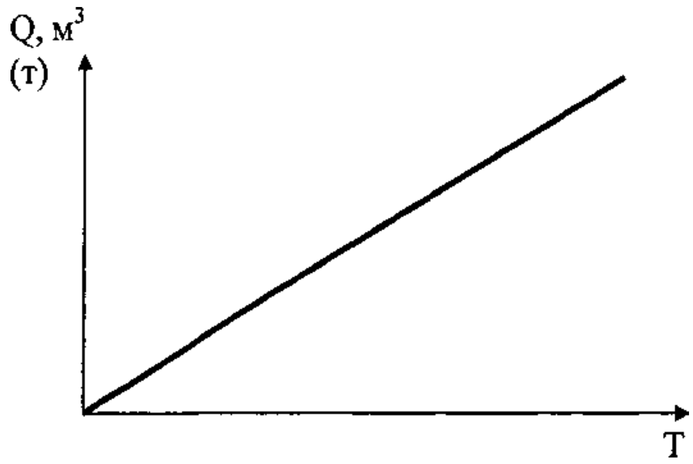

Figure 1. Excavator output when developing soil into a dump

In reality, it is discontinuous. The transition of this system from state i to state i+1 occurs under the influence of excavating the next portion of soil and placing it in a dump in a time equal to one cycle.

Thus, the state of the system "developed object - excavator - dump" (hereinafter referred to as the "system") begins every shift from state S_0 (when not a single cycle has yet been completed, i.e. not a single bucket of soil has been sent to the dump). Such a system changes its state over time, moving sequentially from the S_0 state to the S_n state (when n portions of soil are dug out and placed in a dump). The operations of the excavator process develop as random events, the nature and outcome of which depend on many random reasons. The transition of a system from one state to another occurs "in a jump", and since each portion of soil placed in a dump can be listed (numbered), then, according to the provisions of the theory of operations research [2], the process of operation of the "system" (excavator) is discrete.

The labeled state graph of the "system" (excavator) can be presented in the following form (Fig. 2)

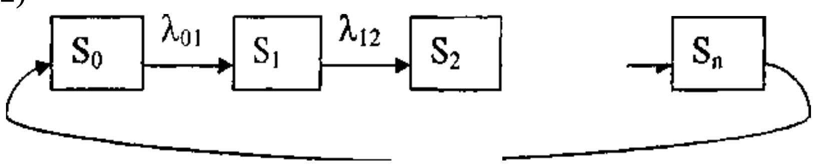

Figure 2. Graphical state of the operation of the system "developed object - excavator - dump"

According to the presented graph, the "system" from state S_0 one-sidedly transitions sequentially to the next state:

S_1 - one portion (bucket) of soil was dug up and sent to the dump;

Si - excavated and sent to the dump i and portions of soil;

S_n - p portions of soil were dug up and sent to the dump.

But every shift such a system returns to its original state S_0. This transition can be carried out from any state S_j. Moreover, if the i^{th} number of soil portions is equal to the planned one, then the replacement plan has been completed. Consequently, the process of operation of the “system” (excavator) is in fact a cyclic random process with a discrete state, which can be characterized by the number of complete cycles (portions of soil) completed over any period of time.

As follows from the above, the idea of the continuity of the excavator operation process does not correspond to real work, and for a correct assessment of the influence of operational factors and when developing a mathematical apparatus for describing these systems, a necessary condition is to consider the discreteness of the excavator operation process.

Another type of system in which excavators operate, as shown in the classification, is one where excavators interact with vehicles. For example, in reality there are systems where an excavator, working in a quarry, excavates soil and loads it into vehicles, which in turn transport this cargo to unloading points. The simplest system scheme is when cargo (sand, clay, crushed stone, coal, etc.) is delivered from one excavator to one consumer.

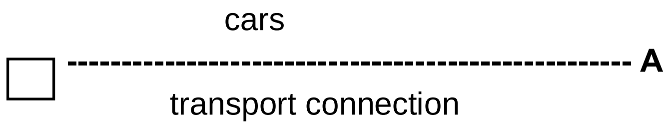

Figure 3. Diagram of the system where the excavator interacts with cars: □ - excavator; A - consumer (car unloading point)

In accordance with the presented diagram, the excavator is a loading point, and the vehicle operating there is a means of delivering cargo, and the production cycle ends at the destination. Such a system, as a result of a delivered portion of cargo (q_y is the actual load of the vehicle), also sequentially transitions from state S_0, when not a single portion of cargo has been transported (not a single trip has been completed), to state S_z, when a certain number of trips have been completed and, therefore, several portions of the cargo were delivered.

The excavator in the system under consideration begins the production process and works until the vehicle is loaded. After this, its operation stops and starts again from the moment when the next car arrives for loading, or when the car returns for re-loading (in the case when one car is used in the system). The amount of cargo can be presented to the consumer (customer) and measured only at the destination after completing the trip. Consequently, the entire system moves into a new state at this point in time - the next portion of cargo has been delivered.

In the time intervals between loadings, the excavator, despite its potential capabilities, does not perform any work.

At time tj, a car is delivered to the excavator for loading, and at this point in time the excavator begins the process of developing soil or minerals and places this portion of the load (equal to the capacity of the bucket) into the body of the car. The process of loading a car continues until time t2 and a portion of cargo equal to

$$Q = q_{кэ}\text{-}m,\ \mathrm{m}^3(\mathrm{t}), \quad (1)$$

where q_{K3} - excavator bucket capacity, m (t);
m - number of excavator operating cycles required to fully load the vehicle qy. According to recommendations [9], the value t=3-6.

qy

$$m = \frac{}{q_{кэ} \cdot y}. \qquad (2)$$

where q - vehicle load capacity (body capacity), t (m);
y - capacity utilization factor.

At time t_2, the operation of the excavator in the system under consideration stops and resumes again at time t_5, etc. Thus, by time t_6 the excavator will carry out the second loading and two portions of cargo will be sent to the consumer. As follows from the description, in this case, the operation of an excavator is a discrete process interconnected with the operation of the vehicle, and therefore cannot be described by a known dependence.

The movement of a car with a load begins from time t_2 and until time t_3 it moves to its destination, where the load is released at time t_4. At the same moment, the load can be recalculated (weighed, etc.), so the "excavator-vehicle" system has abruptly moved to a new state S_1 - a portion of the load equal to the actual load of the vehicle used has been delivered (driving). As you can see, the transition of such a system from state to state occurs under the influence of the delivery (ride) of a portion of cargo to the destination, and since each portion (ride) can be listed, the production process of the "excavator - car" system is discrete.

If the system has several vehicles delivering soil to one consumer, then such a system is closed and connected, i.e. all cars perform their operations sequentially one after another.

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